DOCUMENT RESUME

ED 309 939 SE 050 773

AUTHOR Haley-Oliphant, Ann E.
TITLE Mind Games: A Study of Hypothetical Questioning in a Science Classroom.
PUB DATE 87
NOTE 37p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (60th, Washington, DC, April 23-25, 1987). The preparation of this paper was sponsored in part by a grant from the United States-Spanish Joint Committee for Educational and Cultural Cooperation, Ministry of Exterior Affairs, Madrid. Figures 1 and 2 contain marginally legible type.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Cognitive Processes; Cognitive Structures; Junior High Schools; *Learning Processes; Learning Strategies; *Questioning Techniques; *Science Instruction; *Science Teachers; *Secondary School Science; Teaching Methods

ABSTRACT

The purpose of this study was to examine the thinking underlying the questions posed by a science teacher to her seventh grade students in an instructional activity called Mind Games, in which hypothetical situations focussed on scientific issues are proposed and explored at least once during each major instructional unit. Mind games are conveyed to the students mainly through a series of questions, and this study examined the origins and functions, characteristics and preparation, interaction and evaluation involved in this line of questioning. The study which was designed after considering recent research on teacher thinking, the complexity of the classroom and the use of questions by teachers, was conducted in a suburban junior high school with a teacher having 5 years teaching experience at an inner city school and 2.5 years at the suburban school. Naturalistic methods were used to acquire the data, including field notes, audiotape and videotape recordings, and structured interviews with the teacher and the students. Data were analyzed using the technique of constitutive ethnography. Preliminary findings indicate that the line of questioning employed has two functions. First, the hypothetical situations examined serve to provide the opportunity for students to engage in critical and creative thinking and to give the teacher and the students a chance to make science "wonder-full." A series of characteristics for these hypothetical situations has been made and the phases that occur during these situations are being analyzed. (CW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED309939

MIND GAMES: A STUDY OF HYPOTHETICAL QUESTIONING IN A SCIENCE CLASSROOM

Ann E. Haley-Oliphant
University of Cincinnati

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Ann Haley-Oliphant

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Paper presented at the annual convention of the National Association for Research in Science Teaching, Washington, D.C., April 23-25, 1987.

The preparation of this paper was sponsored in part by a grant from the United States-Spanish Joint Committee for Educational and Cultural Cooperation, Ministry of Exterior Affairs, Madrid. The opinions expressed do not necessarily reflect the position of the Joint Committee, and no official endorsement should be inferred.

SE 050 773

BEST COPY AVAILABLE

MIND GAMES: A STUDY OF HYPOTHETICAL QUESTIONING IN A SCIENCE CLASSROOM

- Is Halley's comet going to be around in 2000 years?
- If the sun were to become a supernova, will the Earth be destroyed immediately or will it take a while for the Earth to be destroyed?
- You need to pretend that the technology has advanced so far that you can visit each of the planets. You'll have to tell me what you found... what things you have to take with you to survive...You will have to use your imagination to figure out how to land on each planet...

These questions are used in a seventh grade classroom to initiate an inquiry activity called "Mind Games." The purpose of this paper is to explore the thinking of a science teacher surrounding the nature of the questioning process in the context of science instruction. Mind Games will be used as a particulary successful interactional context to examine how questions are used by the teacher to shape activity, teacher-student interaction during inquiry, and the relationship between teachers' goals, knowledge and action and the questioning process. The theoretical basis of this research comes from four areas: questioning research, research on classrooms as complex social systems, research on teaching and learning, and activity theory.

Teachers' questioning of students has been a focal point of numerous studies in the past two decades. The research on questioning has been greatly influenced by Bloom's Taxonomy of educational objectives (1956) even though it was not intended for such use. Bloom's taxonomy has been used to categorize the questions asked by teachers into cognitive levels ranging from lower level to higher level questions. Research has been done to ascertain the cognitive levels of questions (Gall, 1970,

Hargreaves, 1984, Nasca, 1983); to determine the proper utilization of questioning strategies by teachers during recitation and discussion (Dillon, 1981b); to discover the effects of teacher questions on the level of student participation, involvement and achievement (Dillon, 1978); and to prepare prescriptions as to how questions should be asked in the classroom (Dillon, 1981b, Napell, 1977) Researchers have counted, labelled and categorized questions (Dillon, 1981a; Winne, 1979; Redfield and Rousseau, 1981).

The manner in which teachers ask questions has been examined by several researchers. Mishler (1975) believes rapid fire questioning by teachers serves to maintain control over social and verbal behavior in the classroom. Napell (1977) argues that these rapid fire questions prevent students from having time to reflect and formulate answers. Rowe (1974) examined the wait-time between teacher questions and student responses. Rowe found significant improvement in the intellectual and interpersonal climate of the science classroom when teachers did implement wait-time. Tobin (1985) looked at the use of wait-time in whole class settings. He found teachers to interact with a relatively small group of target students when questions were asked to bridge content areas and to stimulate thinking. The target students appeared to be those students providing appropriate responses for the teacher to use in subsequent instruction. Tobin suggests extended wait-time may be benefitting target students to a greater extent than it would non-target students especially if the non-target students were not being attentive to the content of the peer target responses.

Textbooks used in content area methods courses for preservice education students often have chapters devoted to appropriate questioning techniques. Carin and Sund (1985) present the classification system of questions: convergent and divergent, Bloom's taxonomy, critical thinking and multiple talent. Convergent questions have

few responses while divergent questions are open-ended. Bloom's taxonomy may be used to focus on levels of questioning related to levels of thinking. Operations presumed to underlie responses to higher cognitive questions most closely correspond to application, analysis, synthesis and evaluation within Bloom's taxonomy. Redfield and Rousseau (1981) performed a meta-analysis and concluded that the predominant use of higher level questions during instruction has a positive effect on student achievement. Multiple talent questions generally involve "Who would like to.." and serve to enhance the teacher's knowledge of the students (Carin and Sund, 1985). Dillon (1978) maintains that questions can inhibit participation and do not necessarily stimulate it. Dillon (1981a,b), Hoetker and Ahlbrand (1979), Mishler (1975) and Rowe (1974) found answers to teacher questions being brief and simple with few voluntary comments. Dillon (1982b) suggests teachers use direct statements to enhance students' responses.

Questioning is generally the instructional strategy used by teachers during discussions and recitations. Dillon (1986) states that teachers need to know what the students truly think (in a discussion) and know (in a recitation). For the past few years, two dozen scholars have been collaborating in a multidisciplinary study of questioning and discussion (Dillon, in press). All have analyzed the same set of five high school discussions. Macmillan focused on the logic of the questions put during a whole lesson. Sigel examined the linguistic types of questions and statements in terms of their demand characteristics. His claim is that teachers presenting an open-ended discussion are more demanding and thus potentially more facilitative of cognitive growth. Farrar attempted to discern the teachers' underlying or tacit conceptions of teaching. She found three implicit conceptions of teaching in the discussion interactions: discussion as being course covering, as expressing and as integrating. Farrar maintains that we cannot make normative

judgments about what discussion strategies and patterns to recommend until we have a more informed idea of what constitutes the various complex patterns of interaction during discussion. Lighthall suggests the data base is limited since there is no further knowledge of teachers' and students' mind states and of larger contexts. Without this knowledge, the effect and relevance of the discussion activity is unknown. Roby classified the transcipts into five kinds of discussion, such as the "bull session", "quiz show", "dialetic discussion", "informational discussion", and the "problematic discussion." He sees each type of discussion as being characterized by a particular rhetoric of questioning and usage of given types of questions. This multidisciplinary analysis provides an illuminating view of the complexity surrounding discussions and questioning in the classroom.

Other researchers have examined classroom environments suggesting that classrooms are complex social organizations that must be examined in context to understand the relationship between the teacher and students (Cazden, 1986; Doyle, 1986). Doyle (1986) argues that classroom settings have distinctive properties affecting the participants, such as unpredictability, multidimensionality and the constant press for immediate action. These characteristics of the classroom environment suggest the difficulty that can arise by performing research where behavior is merely counted, categorized and labelled out of the context from which they occur. The research where behaviors are simply labelled or categorized ignores the fluidity and change that can occur in a classroom over a period of time.

Research on learning and teaching describe teaching as a complex professional activity. Cognitive learning theory portrays learning as a process controlled by the learner as he/she tries to understand the environment (Estes, 1978). Working from this framework, people portray teachers as facilitators of the learning process rather than controlling it. Teachers are responsible for creating an environment to

encourage learning. Teachers create the appropriate environment through problem solving and decision-making. Research on teacher thinking (Clark and Peterson, 1986) portrays the teacher as a problem solver involved in providing appropriate tasks for students based on their needs, aptitudes and attitudes. Some recent research on teacher thinking views the teacher as being a professional engaged in a "reflective conversation" with the immediate situation (Yinger, 1986).

Finally, in attempting to understand the teaching process, the interaction between knowledge and action is the key component. Yinger and Dillard (in press) discuss the work of Soviet psychologists, Vygotsky and Leont'ev on activity theory. Activity theory tries to bridge the gap between thinking and action. It sees thinking and action in a holistic and constitutive fashion. "The power of activity theory is in its ability to unite thought, action and context" (Yinger and Dillard, in press, pp.9).

These areas of research point to the necessity of examining how teachers think about the questions they use in their classroom. The manner in which teachers plan their questions, their goals for asking different kinds of questions, and the role of the teachers' content, curricular and student knowledge need to be studied if we are to understand questioning. Research needs to be done to examine questioning more closely to discover how thought and action combine in the complex, multidimensional classroom.

This long-term naturalistic study looks at the thinking of a science teacher surrounding one inquiry activity called Mind Games. Specifically, the following questions guided this research:

1. How does a teacher think about Mind Games? What is thinking-in-action directed toward with regard to these Mind Game questions? What knowledge,

goals and operations are a part of this thinking? Specifically, what role do Mind Games play within a unit of instruction?

3. What is the nature of the activity called Mind Games? What is its form, content, and characteristics?

4. What role does questioning play within the context of Mind Games? How can the teacher/student interaction be described during a Mind Game?

METHOD

This study is part of a larger international study being conducted by two research teams (Yinger and Villar, 1986). The United States group studied three teachers in Cincinnati, Ohio. The Spanish group studied 21 teachers in Sevilla, Spain. The project is a cooperative research effort aimed at broadening our conceptions of teachers' thought processes during teaching.

This research project was a naturalistic study of a seventh grade science teacher at a suburban junior high school, "Colter Bay Junior High." The science teacher, Ms. Jenny Moran, has 7-1/2 years teaching experience involving 5 years at an inner city school and 2-1/2 years at Colter Bay. Data were collected in the classroom from October, 1985 to June, 1986. Data continue to be collected from September, 1986 until June, 1987.

The research was conducted by means of participant observation during planning and teaching, formal and informal interviews, collecting personal journals and documents, and by audio and videotaping classroom instruction. Traditional procedures for naturalistic inquiry were used to guide data collection and analysis. (e.g. Agar, 1980; Pelto and Pelto, 1978). The data set for this analysis includes:

fieldnotes from 65 days of participant observation, 39 days of audiotaped instruction, videotapes of an entire instructional unit (14 consecutive lessons), 12 formal and informal interviews with the teacher and students, and miscellaneous planning and teaching documents.

Setting

Colter Bay Junior School is the only junior school in a suburban school district serving families with a cross section of incomes, from a small minority of low income families to the majority of middle and upper-middle class families. Colter Bay Junior High houses 996 students in grades 7 and 8 with 98 percent of the students being Caucasian. During the 1985-86 school year, the 458 seventh graders were divided into clusters of 125 students. Each cluster is taught by a common core of teachers. Each teacher specializes either in language arts, math, science or social studies.

The seventh grade science curriculum center on earth science and covers such topics as weather, oceanography, paleontology, geology, and astronomy. In the 1985-86 school year, the teachers used a newly adopted textbook as well as a revised graded course of study. This graded course of study included the goals, philosophy, and objectives for the teaching of science throughout the district and was prepared by a committee of teachers representing different grades and science courses during the previous school year.

For this study, the fourth and fifth period classes (upper and middle ability students, respectively) were observed during the school year of 1985-86. The third period class (middle ability students) was observed during the 1986-87 school year. The fourth and fifth period classes were observed because they formed one of the two

sets of back-to-back classes with which the teacher was involved. That is, there was no break due to lunch, planning period or a science help session. This schedule provided the opportunity to observe the teacher's behavior for a longer, uninterrupted period. During the second year of the study, the third period class was selected as it followed Ms. Moran's planning period and enabled the researcher to conduct partial interviews and to observe her planning.

The Participant

Ms. Moran began teaching at Colter Bay Junior High during the 1984-85 school year as a full-time substitute science teacher. She is the only female science teacher in the school. During the 1970's, she taught science for five years in an inner city school. She then left teaching for eleven years and earned two Masters degrees (one in guidance counselling and one in special education with a focus on emotionally disturbed children). Her bachelor's degree is in zoology. She was hired by a local inner city public school system to teach science. She did her student teaching while being employed full-time by the district.

WHAT ARE MIND GAMES?

The focus of this section will be to define Mind Games and to present how Ms. Moran thinks about Mind Games by describing the interaction between her knowledge, goals and actions within the instructional activity of Mind Games.

Mind Games are inquiry activities centering on hypothetical situations posed by Ms. Moran at least once during each major instructional unit. Although the inquiry theme is the same for all Mind Games and the operations are similiar, each Mind Game is contextually unique. Since Mind Games can take the form of a discussion, a debate or a project where students devise a game, diorama, drawings or report, the interaction during these types of Mind Games is vastly different depending on the interaction between the teacher and her students, between the students themselves, and between the individual student and his/her project.

The major operation Ms. Moran employs in delivering the Mind Game to the students is through the use of a series of questions. The language used by Ms. Moran during these questions reflects a stance toward her teaching and students' learning conveying puzzlement, uncertainty, wonder and possibilities (Bruner, 1986). Stance indicates implicitly to the listener how one views the listener or the propositional content of one's message (Feldman, 1976). Through the language of what if, might, what would the world be like, why or will it eventually disappear, and here's the problem, what will we eat, she's trying to convey her major goals and her primary image of what science is to the students. The world of science Ms. Moran is presenting to her students is one where hypothetical situations are eagerly examined and pondered. Mind Games serve to unite the students' prior experiences and education with the activities and operations employed by Ms. Moran during her

teaching. A Mind Game is played only after an adequate amount of subject matter content and laboratory experiences are provided to the students. Ms. Moran describes a Mind Game below:

> It's a game they play in their minds where "What if?"; "What would happen?"; and "Why?" The lecture is just plain facts and information that the kids will have to pull out to play the Mind Games. The game is merely "Why this?"; "Why not this?"... As long as they come up with a valid reason for what they give me then nothing is too off the wall because basically there are certain basic scientific principles you have to hold to with theories of why things happen. But a majority of times, the discoveries have come from people who have taken bazaar concepts with a reputation of "This will never work." These people took these concepts and made them work. (2/19/86)

The knowledge and goals Ms. Moran holds for her science teaching focuses not only on content but is also combined with related pedagogical concepts and strategies, such as the belief in the scientific inquiry method, creativity techniques and problem-solving skills (Yinger and Dillard, in press). Her stance affords students the chance to ponder about the marvels of science, to ask themselves "How can this be?" and "What is going on here?" As Alice travelled through her looking glass looking for adventure and possibility, Ms. Moran seeks to temporarily transform the adolescent science student into a dreamer travelling through the wonderland of science where impossibilities become possibilities, where ideas are the stuff of which progress is made and where the imagination accompanied by reasoning transforms a current day problem into a solution for tomorrow.

Being the pinnacle of her instruction, Mind Games provide Ms. Moran the opportunity to see how the students integrate their prior experiences, beliefs and creativity with the activities and operations she provides them during the specific instructional unit. In turn, this information aids Ms. Moran in her knowledge of the adequacies and deficiencies of her teaching. This knowledge provides the foundation for her to remediate a Mind Game as it is being played and to revise her

Mind Games for future use. For example, Ms. Moran says that a Mind Game bombs when the students are unable to provide any ideas to the questions posed. She cites this as a lack of prerequisite skills which means "I have to go back and teach it again." Also, an unsuccessful Mind Game occurs when the students non-verbal behavior indicates to Ms. Moran that they are not having fun with the question. "I have to come up with another question really quick to bring their interest level up again." (2/19/86) This quote is best explained by the work of Schon (1983) who portrays this as reflection-in-action referring to on-the-spot thinking allowing a teacher to fine tune action based on the "back talk" of the situation. By monitoring the students' verbal and non-verbal actions, Ms. Moran receives a tremendous amount of feedback as to the success of her Mind Games. This is the particular information she uses later in her reflection on past Mind Games.

The Goals of Mind Games

The concept of Mind Games came to Ms. Moran after her first year of teaching. After working with inner city students, she saw the need for them to voice their opinion. This need served as the framework for her goals in incorporating Mind Games into her repertoire of teaching activities. First, Mind Games are provided to encourage students' critical and creative thinking skills regarding scientific topics. Ms. Moran believes her adolescent students are capable of exploring scientific issues. One Mind Game focused entirely on the recently discovered holes in the ozone layer. The students were to explore ways in which life as we know it would be affected in 100 years if the holes continued to be developed. A few of the ideas from the students included penalizing companies who manufacture chemicals known to affect the ozone layer; the destruction of land caused by the melting of

the ice caps and subsequently flooding the farm land; the adaptation of plants and animals to the new climactic conditions; and the construction of cities with protective domes to screen out the ultraviolet light. As the students presented their ideas, Ms. Moran made comments such as "Is that what would happen?", "How do you know?", and "What do you foresee us doing?" The stance exhibited in these questions reflects an attitude of eagerness, of wonder, and of puzzlement. She is implicitly conveying her goal of getting students to ask questions about the world around them until their curiosity is satiated.

During Mind Games, the students act as the experts expousing their ideas and offering their solutions while Ms. Moran plays several different roles. She may act primarily as a catalyst in igniting the students' imaginations, as a moderator, as a praiser, or as a Devil's advocate. All of the roles Ms. Moran plays are seen as important means to reach her goal of maximizing students' use of creative and critical thinking skills.

Second, Mind Games serve as the climax of her instructional teaching units. During Mind Games, the students are to pull together the content they have been exposed to during the preceeding lessons, combine it with the knowledge they hold from everyday life and past experiences, and create a solution to the Mind Game posed by Ms. Moran. The following quote illustrates:

> ..what has to be taken into account is every experience a child has, each child sees differently. Two children may have the same experience and relate to it totally different... Their Mind Game answers will be premised on how they experienced the topic... They could have given me two totally different answers coming from two totally different experiences, but both would be right. (5/21/86)

Ms. Moran values the past experiences of her students and her Mind Games are a way of expressing to the students the value she places on individual experience and the role she wants those experiences to play in the classroom. For example, the Mind

Game for the paleontology unit involved the students in a role play situation where they were to become an extinct life form and describe who they were, how they lived, how they were fossilized and whether they were index fossils or not. One middle ability student created a tape recording of a news broadcast where a trunk was found with taped interviews from a 200-million-year-old relative of the cockroach. The student incorporated his knowledge of the subject matter and the mass media with an unusual blend of creativity and humor to generate his own unique answer to the Mind Game.

An example of a Mind Game providing a chance for the students to integrate their knowledge is during the astronomy Mind Game focusing on Halley's comet. Ms. Moran posed the question "Will the comet cease to exist?" Although this was a more rigid type of Mind Game where an answer is arrived at during the discussion, Ms. Moran provides a description of the information students had to consider in playing the Mind Game:

> The students had to take into account that the comet shows up only 70 some odd years. They had to take into account that if it does disappear-- what happens to it? Or if it doesn't disappear, but it does melt-- where does it go? All those things require basic science concepts. Ice is frozen; as it gets near heat-- does it melt? What else is a comet made of? Is it moving too fast around the sun to do any melting? Can you move too fast not to melt? (5/21/86)

This quote illustrates the basic science concepts and generalizations Ms. Moran expects the students to have mastered. Her language also elucidates her stance toward considering possibilities and uncertainty in the subject matter that Ms. Moran conveys to her students while playing a Mind Game.

Third, Mind Games are a vehicle Ms. Moran uses to foster socialization skills in her students. She seeks to influence the quality and quantity of students' responses to her Mind Game questions by moving them from typical monosyllabic

replies found in recitations to lengthy statements supported by their reasoning. During this study, as both school years progressed the number of "Gee, I don't know" statements markedly decreased and the length and quality of the comments provided by the students increased. Often, the length and number of student comments far exceeded Ms. Moran's discourse during an oral Mind Game." Ms. Moran made 67 requests to the students to be creative, to think and to argue during a Mind Game held in the beginning of the school year. By the end of May, she made only 28 similar requests. The number of student comments or questions directed to other students rose from 18 in the beginning of the year to 34 by the end of the year.

In playing Mind Games, she tries to set up an atmosphere where students can explore the possibilities without fear of mockery from their peers. Setting up this type of atmosphere begins on the first day of school. Ms. Moran waits to play her first verbal (non-project) Mind Game until she is sure the students know how strict she will be about students putting each others' ideas down. She says:

> I don't want to try a Mind Game when they know that other kids can still pick on them for an answer and say "Oh, is that stupid, that will never happen." Because that will turn them off for the rest of the year and I will never get anything out of them. (9/5/86)

Mockery does appear in some of the Mind Games played in the debate or discussion format, but Ms. Moran responds to the situation by carefully extinquishing any derogatory remarks with statements like "Hey, that may not be that far out of an idea." In addition, the student being mocked continues to contribute to the Mind Game. His/her participation does not seem to be affected by the mockery.

Also, Ms. Moran uses Mind Games as a method for inducing the students to argue with one another. Specifically, she will use comments she refers to as "con phrases", such as "Anybody want to argue with Tom?" and "Argue with them, do you

think this would happen?" For example, during the astonomy unit, the students were to think about whether Halley's comet would ever cease to exist:

Tom immediately sits up and says a resounding "NO!!!."
Moran: Why not?
Tom: Because it melts and then when it gets back out again it refreezes.
Moran: No, the stuff is already gone. The solar winds pushed it away so it can't refreeze because it isn't there anymore.
Tom: Then, it recollects it again.
Moran: Does it?
Tom: Yeah.
Moran: Are you sure?
Tom: Yeah.
Moran: Anybody want to argue with Tom?

Several students say a hearty "Yeah." Noises picks up in the class and Ms. Moran has to interject a "Sshhh."
Pat immediately shoots up his hand waving it into the air.

Pat: It doesn't recollect it.
Moran: How do you know?
Pat: I don't know.

Numerous students are interjecting now and talking among themselves.

Moran: If you are going to argue, you must have your reasons.

The class quiets down completely as Ms. Moran says this. As soon as she is finished, the uproar begins and the students demand to know his reasons. Ms. Moran raps her knuckles on her desk and yells "Hold it." During this time, Pat is continually trying to interject his comments.

Pat: They might drift off course so the comet can't come back.
Moran: OK, good. (Low talking among students continues) The gases drift off somewhere. Anybody else? OK, Tom. Go ahead (She acknowledges Tom in an eager manner)

Tom: There is rock and ice floating around that it picks up.

Moran then comments that she won't argue with him and Jason immediately says "I WILL!!" (2/21/86)

The arguing continues between Tom and Jason until Ms. Moran sees the Mind Game becoming a free-for-all between the two boys. Being responsive to the interaction occurring, Ms. Moran halts the arguing between the boys by asking a question directed to the entire class instead of to the three boys. Early in the school year, Ms. Moran frequently begs the students to argue with each other. Ms. Moran sees her school year as being successful if the students eagerly argue with each other by the end of the school year. Having the students argue among each other assists in their adolescent search for autonomy (Milgrim, 1985). Ms. Moran is providing the students with the opportunity to engage in an activity that increases their confidence in their ability to voice their opinions and beliefs.

Finally, the fourth goal for Mind Games is one directed to Ms. Moran. As an activity, Mind Games excite and keep Ms. Moran enthused about her teaching. Mind Games have improvisational characteristics. The notion of improvisation in teaching comes from the work of Yinger and Villar (1986) and "means action that occurs within the framework of some activity but that is spontaneous or extemperaneous-- action that is 'of the moment', composed and developed as being uniquely suitable to the situation at hand" (p. 6). Although, the topics for Mind Games are planned in advance by Ms. Moran and she has some idea of what possibilities the students may raise, there is still a great deal of uncertainty and surprise surrounding each of the Mind Games. When setting up a Mind Game, Ms. Moran cannot predict exactly what comments, arguments, viewpoints and information will be coming from the students. For example, when asked if she ever envisions how a Mind Game is going to be played, Ms. Moran said:

> As I develop them (the Mind Games) I have an idea of where I want them to lead. In some cases, it has lead to other places that have totally surprised me. I've loved it because they (the students) have gone into areas that I didn't think they'd get into. (9/5/86)

> ...to a certain degree after years of teaching, I'm going to get certain basic answers, but every year each group of kids comes up with a totally different answer or group of answers. They always fascinate me, and it depends on how they answer-- I'll alter my Mind Game the next year to encompass what they've come up with, or at least to tease the next group a little into giving me even more than the last group gave. Mind Games alter slightly every year. They're never the same things because they can get stale also. (5/21/86)
>
> In turn, those kids feed my creativity because I always learn somthing from their creativity which I build on for the next group (of students). You have to be flexible enough to learn from your kids. They can teach you a lot. (9/24/86)

The above quotes illuminate a different side of Mind Games than has been described thus far. The improvisational nature of Mind Games are a source of enrichment for the teacher. Her knowledge of self, students, subject matter and context is expanded as a result of playing the Mind Games-- sometimes in totally unexpected ways. After one Mind Game where the students were to build a city under the ocean to escape the increased heat of the earth due to the greenhouse effect, one of the student's projects was going to involve the breakdown of water molecules to produce oxygen for the city. The next day, one of the students in the class had apparently discussed the project with her parents. Input from one of the student's parents, being a chemical engineer, commented how enough heat would be produced by breaking down the water molecules thus keeping the city warm. As a result, the students' and Ms. Moran's understanding of the technology required to live underwater were enhanced by this unpredictable input from the students' parents.

In addition to enriching her knowledge, the improvisational nature of Mind Games is apparent in the necessary responsiveness and flexibility Ms. Moran must display during a Mind Game. In numerous cases, Ms. Moran has been caught off guard by a student, who normally does not excel during lecture and lab activities, coming up with original, thought provoking ideas during a Mind Game. For example, after the students had designed their underwater city, they were to present their cities

in front of the class. One student proposed a city where large tubes were extended from the city up above the water line into the sky. These tubes were to pass the heat and light from the atmosphere down into the city. One middle ability student who is often quiet in class and requires a lot of encouragement in completing her assignments asked "What are you going to do about waves that might come up over the tubes and flow down into the city?" Ms. Moran looked at the student and immediately changed the flow of the game with the following questions which were directed to the entire class: "Do waves go throughout the ocean? Is it just the surface or through the depths of the ocean. Who has an answer? Who has a guess?" (2/9/87) Three students responded and Ms. Moran explained how the city would definitely need some type of machine to provide advanced warning since waves only occur on the surface. This is clearly a case where Ms. Moran's response was "of the moment." First, she was being responsive to the student's project design as well as to the unpredictable comments the students were raising about each other's projects. In turn, this Mind Game afforded Ms. Moran the opportunity to see her students in a new light.

In summary, the goals Ms. Moran holds for Mind Games include the development of critical and creative thinking skills regarding scientific issues in the students; the integration of the students' previous experiences with the activities and operations used in her teaching; the development of the student's capacity to argue and voice their opinions freely in class; and the improvisational nature of Mind Games aids in keeping science teaching exciting and fresh for Ms. Moran. A Mind Game serves as an activity for both teacher and student enabling them to experience the wonders of science where the heights of possibilities are limited only by the depths of imagination and inquiry.

THE CONTEXT AND CHARACTERISTICS OF MIND GAMES

This section will describe the specific context within which Mind Games occur as well as the characteristics of all Mind Games. To illustrate my findings, I present a summary profile of the characteristics and contextual features of eight Mind Games in Figure 1. Figure 2 depicts one Mind Game which will serve as the main example during the following discussion. Several of the descriptors are anchored with a zero. The zero may mean no action was relevant depending on the context. For example, if the Mind Game is in the form of a project, then one would expect there to be no instances where student comments reflect knowledge unaddressed in class. The profile depicting eight Mind Games illustrates how widely varied the form of a Mind Game can take in Ms. Moran's classroom.

The Context for Playing Mind Games:

The context for playing a Mind Game includes the following areas: framing, timing during the unit, length of play, type of class participation, posing of Mind Games with detail questions, the type of instructions given and the operation used to end the Mind Game (Figure 1 and 2). In the 1985-86 school year, seven Mind Games took place. Thus far, four Mind Games have occurred during the 1986-87 school year.

First, Mind Games can occur within the form of a long-term project involving written or artistic work, a debate where groups of students present their arguments to the rest of the class or as a discussion between the students and the teacher. The teacher determines the frame for each of the Mind Games depending on her overarching goals and her knowledge of the subject matter. From Ms. Moran's experience with Mind Games, adolescent learners and scientific issues, she designs her Mind Games in a connected manner. For instance, she has found from past

experience that the scientific content of some Mind Games lends itself more to being played in the written or drawn form than through verbal discussion. This knowledge is then connected with the goal of providing a creative and imaginative outlet for the students and sets the frame for the project-oriented Mind Games. Ms. Moran's goal for socializing the students is sacrificed during these kinds of Mind Games at the expense of creativity; however, Ms. Moran still alludes to the socialization goal by allowing students to consult or work with one another and to "use each other as a resource." Likewise, Ms. Moran has found some of the scientific material more conducive to discussion and debate. This, in turn, is connected with her goal to increase the socialization of her students. Creativity is expressed in the students' answers but does not occupy the primary position as in the project Mind Games.

The timing of a Mind Game can occur in the formative stages or as a summative activity of an instructional unit. Mind Games as summative activities always occur as projects. The students are given two to four weeks to complete their Mind Game. Mind Games framed in discussions and debates generally occur during an instructional unit after the students have been presented with a certain amount of content information. A Mind Game played in the form of a debate can be expected to take at least 1-1/2 class periods; whereas, a discussion can take as little as 5 minutes or as much as 1-1/2 class periods. In all cases, Ms. Moran determines the ending of Mind Games. Mind Games end in several ways: a project can be turned in to Ms. Moran, a homework assignment can be given to further investigate the topic of the Mind Game, or Ms. Moran can summarize the Mind Game by providing additional content information or by furthering her initial invitation to the students to contemplate and consider the possiblities surrounding the topic.

Generally, Mind Games are presented to the students through the use of a series of aspect or detail questions linked with specific content information. For example, one Mind Game was devoted to the topic of the ozone layer. This Mind Game occurred in October, 1986 during the weather unit. By looking at Figure 2, this Mind Game was in the form of a discussion, occurred during the unit, took 1-1/2 class periods to play, and ended with a teacher summary. Prior to playing this Mind Game, the students had been working on weather station models, making barometers, and working with concept of latent heat. After the ozone Mind Game concluded, the greenhouse effect was studied. National reports about the destruction of the ozone layer had been in many of the newspapers and on television. The night prior to playing the Mind Game, Ms. Moran commented to the researcher about revamping the ozone Mind Game from last year to include the entire world instead of just Cincinnati. She was becoming bored with responses only dealing with Cincinnati. Ms. Moran presented this Mind Game to the students as follows:

> We talked about the ozone layer a couple of days ago and we also talked about the fact that scientists think there is a hole in the ozone layer....What I want you to do for a few minutes is to think real seriously (pause and drawn out) whether or not you truly believe the ozone layer: #1 really does keep out ultraviolet rays and #2 if the ozone layer does keep out the ultraviolet rays and keeps the earth from getting to hot, then I want you to think of what will happen if there are truly holes in the ozone layer.... I want you to stop and think about what the world would be like 100 years from now...

The way in which she emphasizes to "stop and think" is her way of inviting the students into the world of contemplation. The stance in her language reflects possibilities and unknowns through the use of words like "IF," "scientists think," "do you believe," and "what will happen." In initially presenting the Mind Game, she is attempting to draw the students into the processes of science and to kindle their imaginations and thinking skills.

The discussion and debate formats for Mind Games are always initially presented to students in a verbal fashion similar to the one described above. The project Mind Games are presented by providing both oral and written quidelines and instructions. The amount of content and detail questions presented can not be predicted based on the amount of time necessary to play a Mind Game (Figure 1). One Mind Game lasting less than 10 minutes was set-up by Ms. Moran using 17 detail questions while a project oriented Mind Game may only have 2 detail questions.

The Characteristics of Mind Games

A Mind Game is an inquiry activity focusing on a hypothetical, scientific issue. Mind Games are always initiated by the teacher and they never occur spontaneously during classroom discourse. In planning a Mind Game, Ms. Moran is influenced by current scientific reports appearing in scientific journals, popular science magazines, science education journals, television and newspaper coverage and her contact with scientists working in universities and industry. These sources coupled with past experience serve as the springboard to the development of Mind Games. For example, during the oceanography unit when the students were to construct an underwater city, an article in the local newspaper describing an underwater hotel off Key West caught Ms. Moran's attention. From this article, she began speculating what knowledge the students would have to apply to construct their own city under water. Since one of Ms. Moran's goals for Mind Games is to provide the opportunity for students to integrate their prior experiences with their current knowledge gained in the unit, she saw the underwater city affording the students the chance to apply what they knew about volcanic vents, waste disposal, food assembly and distribution, ecological cycles, topography of the ocean floor and characteristics of the ocean itself. For a topic to be considered by Ms. Moran as a contender for a

Mind Game, the topic must deal with numerous interrelated issues thus imparting the students with the opportunity to pull together their prior experiences and current knowledge using creativity and imagination.

Generally, Mind Games deal with a current issue or topic and project that issue into the future, such as wondering if Halley's comet will cease to exist, what if the sun becomes a supernova, what if the ozone layer continues to be destroyed, and what if all nine planets could be visited. Mind Games not specifically looking into the future focus on theories currently being contemplated by scientists or on projecting oneself back into time.

The interaction during an oral Mind Game (discussion or debate) is framed entirely around Ms. Moran's goals for a Mind Game (Figure 1 and 2). The interaction can be characterized in four ways: the teacher using operations geared towards encouraging creativity and critical thinking, socialization of the students, integrating and applying the students' knowledge and the improvisational qualities.

The operations Ms. Moran employs to encourage students to think, to be creative and to be imaginative can be characterized as modelling, praising and commanding. These operations occur most frequently in the beginning of a Mind Game. In the Mind Game focusing on the ozone layer, Ms. Moran presented the topic to them and interspersed the aspect/detail statements and questions with comments like "I want you to think," "I want you to be creative as you like," and "..to think real seriously." These directives are addressed to the entire class. Once the Mind Game was underway, the statements became more commanding if the participation by the students was lacking in creativity, quantity and quality. She would begin addressing individual students who either had not offered an idea or who presented a possibility needing further clarification by using statements with more force in her voice, like "What IS going to happen? Start thinking about it...", "I want you to

exercise your brain..", "Come on what do you think will happen," and "You've got to have SOME idea." Once the students were offering more ideas and possibilities, the number of directives given by Ms. Moran dropped off dramatically to where she shifted to the operation of praising with comments like "Interesting idea," and "We haven't thought of that." In her summary of the ozone Mind Game, she continued to praise by stating "You came up with some ideas I didn't expect you to come up with ... You should be proud of yourselves on how you did with that topic..." (10/29/86).

The operations employed by Ms. Moran to enhance the socialization of the students include directives towards getting the students to argue with one another during Mind Games where arguing is appropriate, arranging the environment enabling the students to work in groups, and encouraging the students to use each other as resource persons (Figure 1 and 2). The most overt attempt at socializing the students occurs during oral Mind Games. As the year progresses, the number of statements or questions posed by students to each other dramatically increases to the point that Ms. Moran's role is one of moderator maintaining order and redirecting thinking if inaccurate logic is presented. An illustration follows:

> During the Mind Game focusing on what will happen to the Earth in 100 years if the ozone layer is depleted, the students slowly began offering ideas. Halfway into the class period, the students started bouncing ideas off each other with Ms. Moran serving mainly as the gatekeeper for who could talk next. Earlier, Todd suggested we move to the moon and Ms. Moran immediately countered with "What about the atmosphere?" Later, Ricky picked the moon notion up again with:
>
> Ricky: Like if they went to the moon, our technology might be good enough to mnake an atmosphere if we could figure out something to make.
>
> Ms. Moran: Ok, good. (She then redirected her attention back to John who had difficulty paying attention and had not offered any ideas earlier). Chad?
>
> Chad: In a 100 years, they should be able to make a dome city like where we could survive then there would be one small problem.. we'd have to

transport things from Earth so that would cost millions of dollars to take the space shuttle back and forth...

Ms. Moran: Alright.

She nods to Jason.

Jason: I really don't think the money matters if we are trying to survive.

Ms. Moran: Ok, Scott.

Scott: I don't think we'd be able to raise enough money to build a dome.

Two students suggest further ideas unrelated to the moon idea and are followed by a student wanting to go back to Todd's original idea.

Eric: I want to add to Todd's point.. we might then build space stations to help living in space.

Chris and Shanda then suggest living in underwater cities (this was said before they studies oceanography and designed their underwater city) or living underground in a hut. Linda adds to Todd's point by suggesting a colony form on the moon.

Chad counters the underwater idea with the possiblity of "What happens if the water gets so hot that it boils? Or, if there is a dome over the city and it is made of glass, it might melt." (10/29/86)

This excerpt illustrates how Ms. Moran's goal for enhancing the socialization of the students is being achieved. The students are hearing each other's comments and responding to them with constructive criticism, addition or approval. In a student interview at the end of the 1985-86 school year regarding the kinds of questions Ms. Moran asks, one student divided the questions into two groups. The first group of questions served "to see if we know the material" and the second "to get our opinions and to see if we understand everything." When asked why Ms. Moran wants their opinions, the student responded "I think it makes it (the class) alot more interesting. Some classmates (the less popular).... well, they have opinions too and a lot of them make a lot of sense and it really makes you not hate alot of people..." (6-3-86). Through her Mind Games, Ms. Moran is transferring the

students into a world where opinions are to be respected, ideas are to be considered and collaboration can result in an increased acceptance of individual differences.

The third goal of Ms. Moran's Mind Games involves integrating the students' prior knowledge and experiences with their current knowledge (Figure 1 and 2). Assessing whether or not the students meet this goal enters into the operations Ms. Moran uses to evaluate the success of a Mind Game. During oral Mind Games, Ms. Moran may ask a question requesting students to consider subject matter covered in earlier grades, such as "Think back to elementary school, who can tell me about the outer planets?" when she is providing further clarification to a point raised by a student. Other times, the ideas presented by the students, both during oral and written Mind Games, suggest areas of interest from former classes, books, films and television. Using the ozone depletion Mind Game as an example, students interjected comments about flooding and erosion, economics in terms of reduced profits, plant and animal adaptations to certain biomes, health risks such as skin cancer and asthma, and travel into space and underwater. These topics were not addressed in Ms. Moran's unit covering the atmosphere. The students integrated their prior experiences with their knowledge of what would happen to the Earth in 100 years if the ozone layer were depleted. Ms. Moran considers a Mind Game a success if the students present a myriad of ideas linking their new knowledge with the old.

Finally, the role improvisation plays in keeping Ms. Moran excited about her teacher enters into the actual playing of an oral Mind Game. Improvisation during oral Mind Games is most easily illustrated in three situations. When an oral Mind Game has begun, Ms. Moran must attend to the fluidity of the interaction by being responsive to the students's verbal and nonverbal behaviors. Though a continual process, one easy way to see improvisation in action during a Mind Game is when a student suggests an idea that is faulty in logic. Ms. Moran's on-the-spot thinking

responds to the faulty logic by asking the student to clarify, to elaborate or by posing a question to the individual student or the entire class designed to rectify the student's point. To illustrate using the ozone Mind Game:

> Todd: Soon, it would get so hot on the earth, we wouldn't survive.
>
> Ms. Moran: OK, what do you foresee us doing?
>
> Todd: Try to go somewhere else where it isn't so hot.
>
> Ms. Moran: OK, go where? Use your creativity, think of something...
>
> Todd: The moon...
>
> Ms. Moran: Does the moon have an atmosphere that we can breathe?
>
> Several students chorus with a robust "NO!!" and eight hands shoot up into the air.
>
> Ms. Moran: Hold it (raises her hand to stop them), let him finish...
>
> Todd: NO, but if it just gets hot enough, we'll have to figure something out.
>
> From this point, the students pick up on the notion of going to the moon and the flow of the Mind Game shifts towards considering this possibility.

From this excerpt, Ms. Moran immediately tuned into Todd's notion of going to the moon by questioning whether the moon had an atmosphere. Her question about the atmosphere was "of the moment" and served to redirect the students' thinking.

The second place where improvisation can be seen is when Ms. Moran may react to student's comments with excitement and wonder using a question like "..we didn't even think about the snow on the mountains, did we?" This question occurred after a student suggested that the snow would begin melting resulting in flooding and runaway soil if the ozone layer disintegrates. In turn, Ms. Moran followed with questions about the mudslide that occurred in South America last year, such as "What caused all that mud to slide? What happened to all the snow on the mountain

volcano? Who remembers?" These questions serve to increase the class's understanding of the idea posed by the individual student. Also, the way Ms. Moran poses these questions serves as a model for the students to see how she applies her diverse knowledge.

Third, Ms. Moran will react to the "back-talk" of the interaction occurring during a Mind Game when she sees the Mind Game digressing into inappropriate areas. She will pose questions to redirect the students' thinking, such as "What about humans?...We've pretty much thought about plants and lower animals.. Let's try the highest animal now.. Let's see if we can come up with a way that man (sic) might survive it (depletion of the ozone layer)..." The constraints of time often enter into Ms. Moran redirecting their attention.

Finally, Mind Games are the essential theme under which Ms. Moran operates. Her goals and knowledge shape the operations she utilizes while conducting Mind Games. The nature of her talk during Mind Games is one of possibilities and the questions posed elevate the students' status from novice learner responsible for only feeding back information to one of problem solver offering viable alternatives to today's scientific issues. The summary continua of eight Mind Games (Figure 1) shows the wide range of contexts and characteristics within which Mind Games are played. Ms. Moran's goals are exemplified in each Mind Game but the way in which these goals are met varies.

IMPORTANCE AND IMPLICATIONS

In this paper, I have presented one teacher's activity which serves as the exemplar of what she wants to accomplish with the students. Making science "wonder-full" is the overarching goal driving Ms. Moran's teaching. Mind Games are Ms. Moran's way of expressing her responsibilities as a teacher to both students and society.

From my analysis, Mind Games share a thematic notion of propelling students into a state of wonder about the endless possibilities surrounding scientific concepts and propositions. This theme occurs within a wide range of diversity among the Mind Games. The aspects of Mind Games that are the same revolve around the goals Ms. Moran holds for them, such as increased socialization, creativity and bridging prior and current knowledge. The form these goals takes varies depending on whether the Mind Game is written or oral and the kinds of interaction emanating from them.

Much of the questioning and discussion research focuses on questioning strategies and techniques (Hyman, 1979; Hunkins, 1972), prescriptions for having effective discussions (Dillon, 1981a, b) and categorizing kinds of discussions based on questions asked (Dillon, in press). A key element missing from this line of research is the thinking behind the action of questioning or discussing. Questioning strategies, techniques and prescriptions make little sense without an in-depth look at the context. What are the goals of the teachers holding the discussions or asking the questions? Counting and labelling the action tells us little of the knowledge and reflection surrounding the activity.

A prescription for Mind Games could be given but without describing Mind Games within the context of Ms. Moran's goals, actions and knowledge, the effectiveness of the activity would be lost. In Ms. Moran's case, it is not her form but her stance

that makes Mind Games work. To say she provides three content statements followed by four aspect questions and encourages her students to think or be creative 40 times during one Mind Game tells us little of the interaction occurring, the spontaneity, and the goals Ms. Moran holds for her Mind Games. "All action is filtered through a dynamic store of knowledge related to subject matter, pedagogy, environments and participants" (Yinger and Dillard, in press). The research on questioning and discussion needs to focus more on the "filter" described above and less on the filtrate because without understanding why teachers ask the questions they do, what influences the teacher's questioning, and what characterizes the teacher's implicit beliefs about students, subject matter and pedagogy, little knowledge can be gained by merely labelling and counting the questions asked. The action and the context must be brought together to fully understand the implications of teachers' questions. From this analysis, the stance Ms. Moran takes in her questioning serves as a vehicle for instruction and provides a new level of understanding of how questions can work in the classroom. By studying the stance of wonder in her questioning, we move from an understanding to an attitude of questioning. This attitude is presented through her questions and beckons the students to question the world around them. Ms. Moran's questioning serves as an invitation to the students to extend their world through inquiry rather than just as a means to relay information. Her questions reflect her attitude of science being an endeavor surrounded by inquiry, curiosity and possibilities. Questioning in this science classroom has far more meaning than merely checking on knowledge and delivering instructions.

Within the context of Ms. Moran's classroom, Mind Games are an effective activity as evidenced by the eagerness of students to participate in both the oral and written forms, by the positive feedback Ms. Moran has received from

administrators and parents, and most importantly, because the Mind Games fulfill the goals Ms. Moran holds for them. When she reflects back on how a particular Mind Game was played in the past and she sees unfulfilled goals, she strives to alter the design.

Finally, Mind Games are one teacher's attempt to attract students to the mysteries of science by setting an air of unpredictability in her classroom. Likewise, Mind Games serve to excite Ms. Moran's teaching because of their unpredictable "of the moment" format. As more instructional activities are analyzed in terms of their interaction with the teacher's goals, knowledge and actions, the link between teacher thought and action will be better understood.

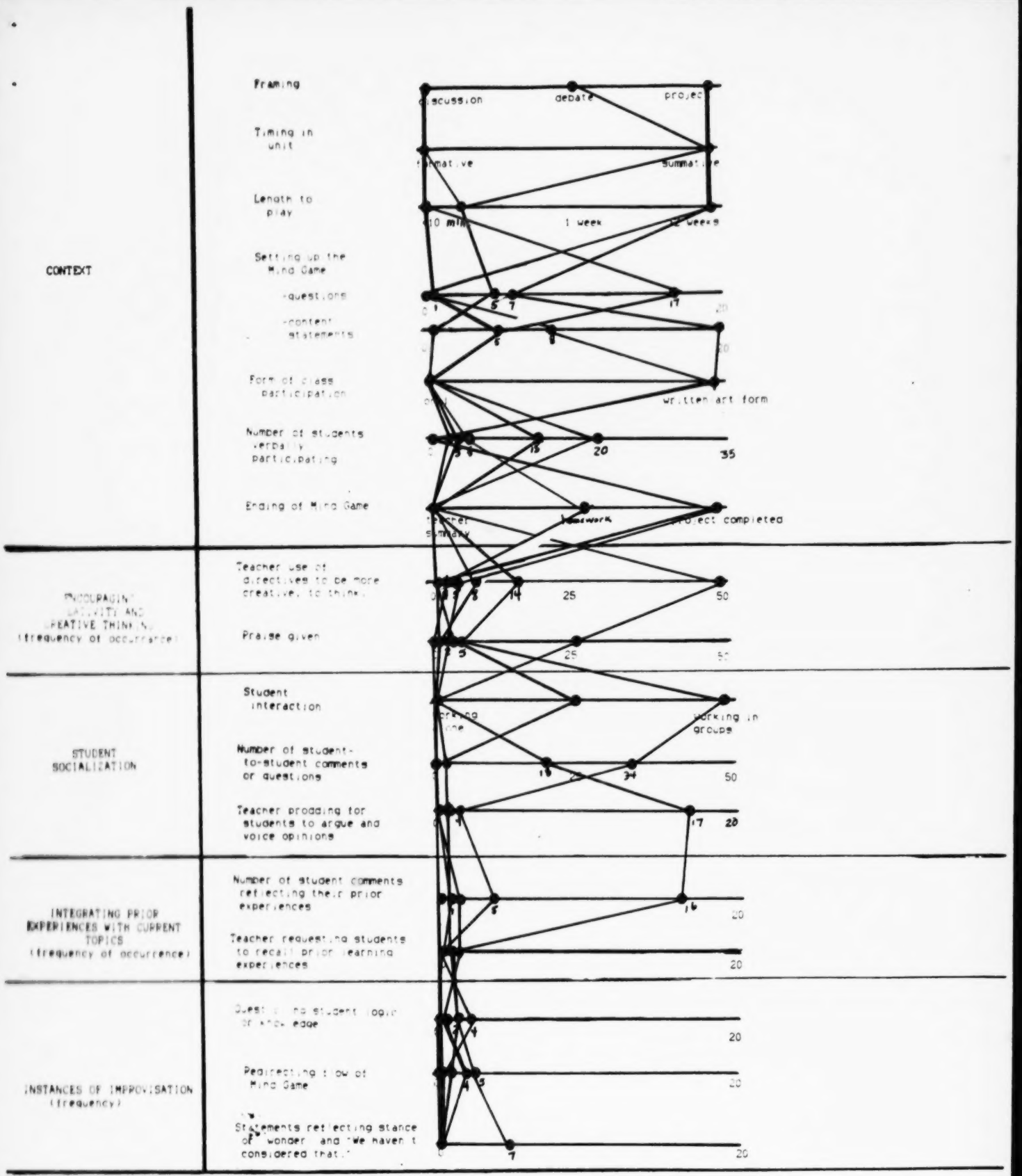

FIGURE 1. Contextual and characteristics continua for 8 Mind Games.

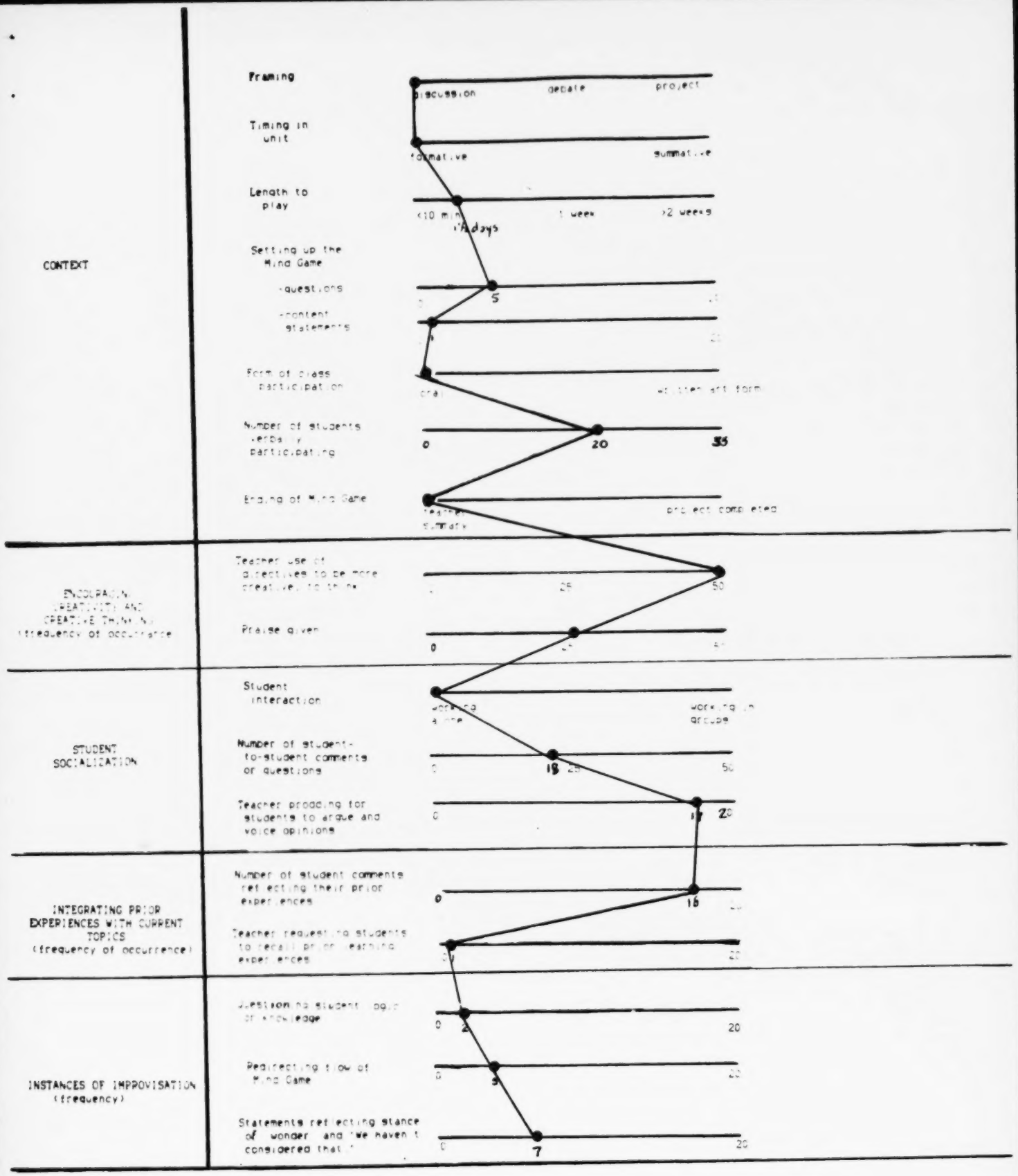

FIGURE 2. A contextual and characteristics continuum for the Ozone Layer Mind Game.

LIST OF REFERENCES

Agar, M.H. The professional stranger: An informal introduction to ethnography. New York: Academic Press, 1980.

Bloom, B.S. (Ed.) Taxonomy of educational objectives, Handbook I: Cognitive Domain. New York: David McKay, 1956.

Bruner, J. Actual minds, possible worlds. Cambridge, MA: Harvard University Press, 1986.

Carin, A.A. and Sund, R.B. Teaching science through discovery. Columbus, OH: Charles E. Merrill, 1985.

Cazden, C.B. Classroom discourse. In Merlin C. Wittrock (Ed.), Handbook of Research on Teaching, Third Edition, New York: Macmillan, 1986, 432-463.

Clark, C.M. and Peterson, P.L. Teachers' thought processes. In Merlin C. Wittrock (Ed.), Handbook of Research on Teaching, Third Edition, New York: Macmillan, 1986, 255-296.

Dillon, J.T. Using questions to depress student thought. School Review, 1978-79, 87, 50-73.

Dillon, J.T. To question or not to question during discussion: I. Questioning and discussion. Journal of Teacher Education, 1981a, 32, 51-55.

Dillon, J.T. To question or not to question during discussion: II. Non-questioning techniques. Journal of Teacher Education, 1981b, 32, 15-20.

Dillon, J.T. Cognitive correspondence between question/statement and response. American Educational Research Journal, 1982, 42, 50-56.

Dillon, J.T. Questioning. In Owen Hargie (Ed.), A Handbook of Communication Skills. London: Croom Helm, 1986, 95-127.

Dillon, J.T. (Ed.) Questioning and discussion: A multidisciplinary study. London: Ablex, in press.

Doyle, W. Classroom organization and management. In Merlin C. Wittrock (Ed.), Handbook of Research on Teaching, Third Edition, New York: Macmillan, 1986, 392-431.

Estes, W.K. (Ed.) Handbook of learning and cognitive processes (6 vols.). Hillside, NJ: Erlbaum, 1978.

Feldman, C. and Wertsch, J. Context dependent properties of teachers' speech. Youth and Society, 1976, 8, 227-258.

Gall, M. Synthesis of research on teachers' questioning. Educational Leadership, 1984, 42, 40-47.

Hargreaves, D. H. Teachers' questions: open, closed and half-open. Educational Research, 1984, 26, 46-51.

Hoetker, J. and Ahlbrand, W.P. The persistance of the recitation. American Educational Research Journal, 1969, 6, 145-167.

Hunkins, F.P. (Ed.) Questioning strategies and techniques. Boston: Allyn and Bacon, 1972.

Hyman, R.T. Strategic questioning. Englewood Cliffs, NJ: Prentice-Hall, 1979.

Milgrim, J. The ninth grader: A profile. In How fares the ninth grade: A day in the life of a ninth grader. Reston, VA: National Association of Secondary School Principals, 1985, 2-9.

Mishler, E.G. Studies in dialogue and discourse. III. Utterance structure and utterance function in interrogative sequences. Journal of Psycholinguistic Research, 1978, 7, 279-305.

Napell, S. M. Using questions to enhance classroom learning. Education, 1977, 99, 188-197.

Nasca, D. Questioning directions for the intellectually gifted. Gifted Child Quarterly, 1983, 27(4), 185-188.

Pelto, P.J. and Pelto, G.H. Anthropological research: The structure of inquiry. Second Edition. Cambridge: Cambridge University Press, 1978.

Redfield, D.L., and Rousseau, E.W. A meta-analysis of experimental research on teacher questioning behavior. Review of Educational Research, 1981, 51, 237-245.

Rowe, M.B. Wait-time and rewards as instructional variables, their influence on language, logic and fate control: Part one- Wait-time. Journal of Research in Science Teaching, 1974, 11, 81-94.

Schon, D.A. The reflective practitioner. New York: Basic Books, 1983.

Tobin, K. Wait-time in science: Necessary but not sufficient. Paper presented at the annual meeting of the National Association for Research in Science Teaching, French Lick Springs, Indiana, 1985.

Winne, P. Experiments relating teachers' use of higher cognitive questions to student achievement. Review of Educational Research, 1979, 49, 13-50.

Yinger, R.J. Examining thought in action: A theoretical and methodological critique of research on interactive teaching. Teaching and teacher education, in press.

Yinger, R.J. and Dillard, J. Thought and action in teaching. In Peterson, P.L. and Walberg, H.J. (Eds.) Research on teaching, Second edition, in press.

Yinger, R.J. and Villar, L.M. Studies of teachers' thought-in-action: A progress report. Paper presented at the meetings of the International Study Association on Teacher Thinking, Leuven, Belgium, October, 1986.